Epitaxial Lateral Overgrowth of GaN using Tungsten Nitride (WN_x) Mask via MOVPE and Electrical Properties of WN_x/GaN Contacts

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Abstract A buried tungsten nitride (WN_x) structure with GaN by means of epitaxial lateral overgrowth (ELO) technique via MOVPE has been investigated. To prevent dissolution of the underlying GaN layer due to the W catalytic effect, is employed as the stripe mask instead of W, where the WN_x mask is produced by a reactive sputtering method using a W target and an $Ar+N_2$ gas followed by a nitridation of the film at 650 ^oC x 15 min in an $N_2 + NH_3$ ambient. The selectivity of the WN_x mask in the selective growth is good and the WN_x film is stable during the growth. A buried WN_x structure with GaN is successfully obtained by the ELO. The contacts of WN_x/GaN after a high temperature annealing of 900 ^oC x 20 min in an N_2 ambient shows an excellent Schottky property with a good thermal stability.

The ELO of GaN with a W metal mask is one of the most promising techniques for obtaining not only buried metal electronic devices but also an ELO-GaN layer with highly crystalline quality [1]. The fabrication of the electronic devices such as PBTs or SITs due to the ELO technique in GaN is very attractive for the use as high power and/or high frequency devices under severe environments such as at high temperature or at highly radioactive environment. Recently, Kawaguchi et al. performed the SAG of GaN using a W mask by MOVPE and achieved high selectivity [2]. However the W metal mask attacked the underlying GaN layer owing to its catalytic effect in the MOVPE growth ambient at a high temperature, so it is difficult to obtain the buried W structure by the ELO [3]. On the other hands, WN_x have clear advantages; (1) good thermal stability under the MOVPE growth condition, (2) reduction in an interface reaction between WN_x and GaN and (3) metal-like electrical conductivity. However, there are no reports on a buried WN_x structure with GaN and the properties of WN_x/GaN contacts. In this work, we performed the ELO of GaN using WN_x mask on GaN by MOVPE and also investigated electrical properties of WN_x contacts on n-GaN.

The WN_x stripe mask of 50 nm thick along the $<1\bar{1}00>$ direction was deposited by a sputtering method using a W target and an $Ar+N_2$ gas followed by a nitridation of the film at 650 ^oC x 15 min in an $N_2 + NH_3$ ambient on an n-GaN epilayer of 4.0 mm thickness grown on sapphire (0001). Then we performed the ELO of GaN using the WN_x mask on GaN at 1090 ^oC x 60 min by atmospherics pressure - MOVPE. Figs. 1 shows the SEM image of the ELO GaN on the mask of L&S = 10&10 μm, indicating that the good selectivity with no crystals on the mask and no degradation of the mask. Furthermore, the ELO GaN on the mask of L&S = 3&3 μm realize the buried WN_x mask structure, as shown in Fig. 2.

In order to investigate electrical properties and their thermal stability of the WN_x/GaN contact, WN_x circular patterns of 300 μm ID was fabricated on an n - GaN epilayer {n = 1 x 10^{17} cm^{-3}} for electrodes. In Figs. 3, the as-deposited sample shows good Schottky contact and furthermore the high-temperature-annealed sample {900 ^oC x 60 min in N_2} also shows much better Schottky contact with less than 1 μA at -10V. Thus, it is found that the WN_x/GaN contact reveals a more excellent Schottky contact after the high temperature annealing. From above results, we expects new GaN electronic device structures of the buried metal contact enclosed with GaN.

References

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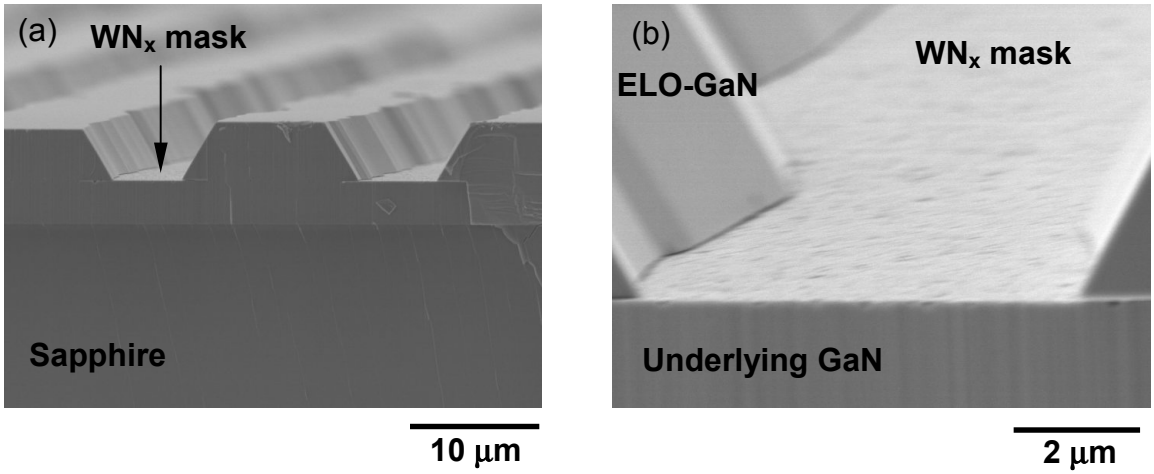

Fig. 1. SEM image of the ELO GaN on the mask of L&S = 10&10 μm (a), enlarged image of ELO GaN near the WN_x mask (b)

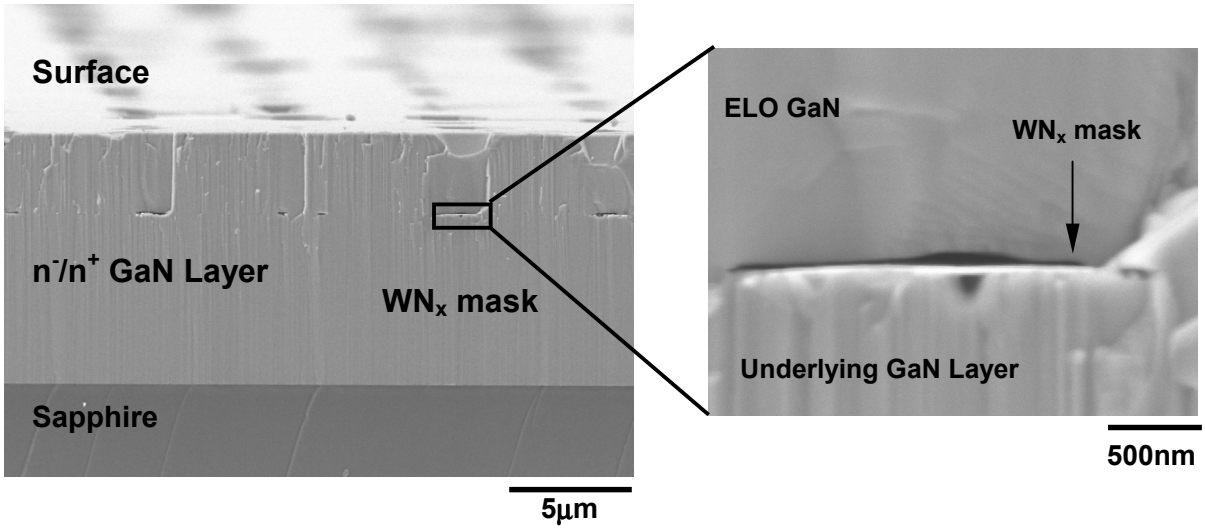

Fig. 2. SEM image of the ELO GaN on the mask of L&S = 3&3 μm

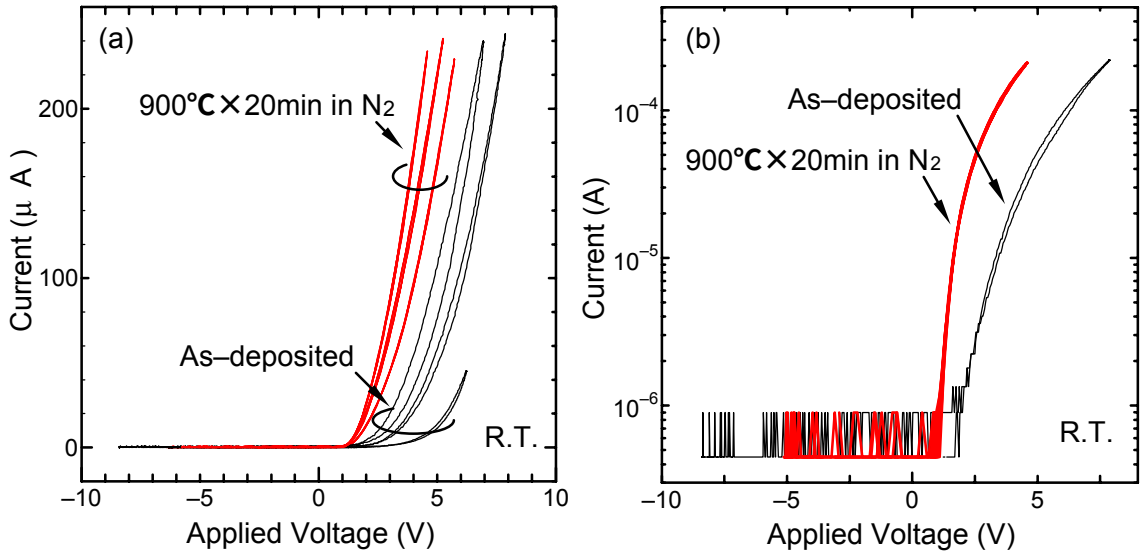

Fig. 3. I-V characteristic of WN_x/n-GaN with linear scale (a) and log scale (b). The current of (b) is the absolute value.